Remarks

The Office Action mailed June 2, 2004 has been received and reviewed. Claim 54 having been amended, the pending claims are claims 45-68.

The specification has been amended to insert new paragraphs at page 3, line 20. Applicants respectfully submit that the amendatory material is the same as the material deleted in the Preliminary Amendment submitted June 23, 2000.

Claim 54 has been amended to recite a "codeposited" diffusion barrier layer, which is supported by the specification at, for example, page 9, line 23 to page 11, line 24.

Reconsideration and withdrawal of the rejections are respectfully requested.

Objection to the Specification under 35 U.S.C. §132

The Examiner objected to the amendment filed February 4, 2004 for allegedly introducing new matter into the disclosure. Applicants respectfully traverse the objection.

"35 U.S.C. 132 should be employed as a basis for objection to amendments to the abstract, specification, or drawings attempting to add new disclosure to that originally disclosed on filing" (M.P.E.P. §706.03(o)). Applicants note that no amendments to the abstract, specification, or drawings were presented in the Amendment and Response submitted February 4, 2004, and thus, respectfully submit that an Objection to the Specification under 35 U.S.C. §132 is improper. Further, although an amendment to the claims was presented, the M.P.E.P. further clarifies, in Examiner Note 3 (M.P.E.P. §706.03(o)), that "[i]f new matter is added only to a claim, an objection using this paragraph should not be made, but the claim should be rejected using form paragraph 7.31.01."

Based on the remarks presented herein above, Applicants respectfully request reconsideration and withdrawal of the objection to the specification.

Applicants thank the Examiner for noting that the specification was amended in the Preliminary Amendment submitted June 23, 2000 to delete material at page 3, line 20 to page 4, line 26. Applicants have amended the specification herein to add the material deleted in the Preliminary Amendment submitted June 23, 2000, at page 3, line 20 to page 4, line 26.

Rejection under 35 U.S.C. §112, First Paragraph

The Examiner rejected claims 50-53 under 35 U.S.C. §112, first paragraph, as containing subject matter which was not described in the specification in such a way as to

reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Specifically, the Examiner alleged that the specification does not support the language "at least one of the . . . second electrode comprises a chemical vapor codeposited diffusion barrier layer formed of $RuSi_x$" (page 3, paragraph 4 of the Office Action mailed June 2, 2004). Applicants respectfully traverse the rejection.

First, Applicants note that claim 50, which recites the language at issue, is identical to claim 32 (now canceled), and that claim 32, which was previously on Appeal, was not rejected under 35 U.S.C. §112, first paragraph.

Second, Applicants respectfully submit that the specification provides adequate support for claims 50-53 to satisfy the written description requirement of 35 U.S.C. §112, first paragraph. Specifically, Applicants respectfully submit that claims 50-53 are supported by the specification at, for example, page 15, line 17 to page 17, line 5 (i.e., a description of Figure 5); and page 8, line 16 to page 11, line 24 (e.g., an exemplary description of formation of $RuSi_x$ diffusion barrier layers).

Finally, Applicants have amended the specification herein to add the material that was deleted in the Preliminary Amendment submitted June 23, 2000, at page 3, line 20 to page 4, line 26.

Based on the remarks and amendments presented herein above, Applicants respectfully request reconsideration and withdrawal of the rejection under 35 U.S.C. §112, first paragraph.

Rejection under 35 U.S.C. §102

Matsubara et al.

The Examiner rejected claims 45-48 and 50-51 under 35 U.S.C. §102 as being anticipated by Matsubara et al. (U.S. Patent No. 5,122,923). Applicants respectfully traverse the rejection.

Claims 45 and 50

"[F]or anticipation under 35 U.S.C. 102, the reference must teach *every aspect* of the claimed invention either explicitly or impliedly." M.P.E.P. §706.02 (emphasis added).

Matsubara et al. disclose, besides other things, a thin-film capacitor. The thin-

film capacitor includes a silicon substrate, an insulating silicon oxide layer, a lower electrode, a dielectric layer of $BaTiO_3$ and an upper electrode of aluminum stacked in sequence from bottom to top (column 3, lines 42-47). Matsubara et al. further disclose that the lower electrode layer was formed by a DC magnetron sputtering technique using a target of sintered Ru or $RuSi_2$ (column 3, lines 48-56). Thus, Matsubara et al. utilize a sputtering technique to form the lower electrode layer of $RuSi_2$.

In contrast, claims 45 and 50 of the present invention each recite a chemical vapor codeposited diffusion barrier layer formed of $RuSi_x$. Matsubara et al. fail to teach a structure that includes a chemical vapor codeposited diffusion barrier layer of $RuSi_x$, as recited in the present invention. In other words, Matsubara et al. describe a sputtered $RuSi_2$ electrode layer and not a chemical vapor codeposited diffusion barrier layer as recited in the present invention.

A diffusion barrier layer formed using chemical vapor deposition as recited in the present invention is different than the layer sputtered according to Matsubara et al. For example, a sputter coated layer, particularly with respect to high aspect ratio structures, provides different coverage thereon when compared to a chemical vapor deposited layer. In contrast, a chemical vapor deposited film provides a highly conformal layer within deep contacts and other openings such as for lower electrodes of storage cell capacitors. *See, for example*, the present specification at page 9, lines 15-17. These highly conformal layers relative to high aspect ratio structures are generally not possible with sputter coating. Thus, the structures recited in claims 45-48 and 50-51, including chemical vapor codeposited layers, are physically, structurally, and patentably distinct from those recited in Matsubara et al.

In support of this position, Applicants submitted a "Declaration Under 37 C.F.R. §1.132" signed by the inventors (filed in response to the Final Office Action dated 25 November 2002) that stated, in part, that there are structural differences between a sputter coated diffusion barrier layer and a chemical vapor deposited diffusion barrier layer. These differences include, but are not limited to, different layer coverage on surfaces having complex geometries. For example, sputter coating a contact hole having a high aspect ratio would typically result in a disproportionately thicker layer of material developing around the opening of the hole as compared to the other surfaces surrounding or within the hole. As a result, the sputter coated diffusion barrier layer may be unable to completely coat the walls and/or the bottom of the contact hole. This would leave regions of the contact hole either not coated or inadequately coated.

In contrast, chemical vapor deposited diffusion barrier layers provide highly conformal and uniform layer coverage on surfaces. This is especially true with respect to surfaces having complex geometries. As such, chemical vapor deposited diffusion barrier layers are more conformal and uniform on surfaces having complex geometries (e.g., openings such as described in claims 57-68) than a sputter coated diffusion barrier layer.

Additionally, structural differences between a sputter coated diffusion barrier layer and a chemical vapor deposited diffusion barrier layer also include differences in the resulting film and substrate qualities. For example, sputter coated diffusion barrier layers can have a high pinhole count as compared to chemical vapor deposited diffusion barrier layers. Also, there is limited stress control possible with sputter coated diffusion barrier layers as compared to chemical vapor deposited diffusion barrier layers.

In addition, an underlying substrate to a sputter coated diffusion barrier layer may have surface damage. This surface damage caused by the sputter coating technique may include implantation of metal into the underlying substrate. For example, ruthenium can be implanted into a silicon substrate surface during the sputter coating of $RuSi_x$. The implanted ruthenium can then diffuse into the silicon substrate. In addition, silicon can be implanted into platinum surfaces during sputter coating of $RuSi_x$, where the silicon can diffuse into the platinum containing substrate. Either example of diffusion into the underlying substrate provides a structural difference between a sputter coated diffusion barrier layer and a chemical vapor deposited diffusion barrier layer.

As such, sputter coated diffusion barrier layers and chemical vapor deposited diffusion barrier layers have different structures. These differences are such that if a chemical vapor deposited diffusion barrier layer and a sputter coated diffusion barrier layer were analyzed by one skilled in the art they would be able to identify the diffusion barrier layer as either being a sputter coated diffusion barrier layer or a diffusion barrier layer having been deposited by a different technique (e.g., chemical vapor deposited diffusion barrier layer).

As stated above, a chemical vapor deposited layer is different than a sputtered layer such as described by Matsubara et al. For example, a chemical vapor deposited layer may be more conformal than a sputtered layer, especially when considering deep contacts and other openings. Further, a chemical vapor deposited layer may exhibit a more uniform distribution of ruthenium and silicide throughout the layer than a layer formed by sputtering or silicidation. Therefore, those skilled in the art would appreciate the structural differences between a chemical

vapor deposited layer and a sputtered layer. The words of a claim must be read as they would be interpreted by those of ordinary skill in the art. *See In re Sneed,* 218 U.S.P.Q. 385 (Fed. Cir. 1983). Those skilled in the art would appreciate that the term "chemical vapor deposited" when used to define a layer describes a structurally different layer than when the term "sputtered" is used to define a layer. As such, the term "chemical vapor codeposited" is not merely a product-by-process limitation and must be given patentable weight in the pending claims.

As a result, Applicants respectfully submit that Matsubara et al. fail to teach all the elements recited in claims 45 and 50 of the present invention. Thus, Applicants respectfully submit that Matsubara et al. fail to anticipate claims 45 and 50 under 35 U.S.C. §102.

Claims 46-48 and 51

Claims 46-48 and 51, which depend, either directly or ultimately, from either claim 45 or 50, are not anticipated by Matsubara et al. for the same reasons as presented above for claims 45 and 50. In addition, claims 46-48 and 51 each provide additional elements that further support patentability when combined with claims 45 and 50.

As a result, Applicants respectfully submit that Matsubara et al. fail to teach all the elements recited in claims 46-48 and 51 of the present invention. Thus, Applicants respectfully submit that Matsubara et al. fail to anticipate claims 46-48 and 51 under 35 U.S.C. §102.

Kuroiwa et al.

The Examiner rejected claims 45-46 and 50-51 under 35 U.S.C. §102 as being anticipated by Kuroiwa et al. (U.S. Patent No. 6,239,460). Applicants respectfully traverse the rejection.

Claims 45 and 50

Claims 45 and 50 of the present invention each recite a chemical vapor codeposited diffusion barrier layer formed of $RuSi_x$. Kuroiwa et al. disclose, besides other things, a semiconductor device including a capacitor, where a lower electrode of the capacitor is a metal electrode 130 mainly composed of ruthenium or iridium that can be deposited by a chemical vapor deposition process (abstract and column 12, lines 25-35). Kuroiwa et al. provide that when ruthenium is deposited by the chemical vapor deposition process, the raw material

may be any one of $Ru(C_5H_5)_2$, $Ru(DPM)_3$, $Ru_3(CO)_{12}$ or $Ru(hfb)(CO)_4$ (column 12, lines 43-49). In addition, the metal electrode 130 can be deposited on the top surface of a silicon plug 111, where "a quick heat treatment is performed at 500° C. to 800° C. for 10 seconds to 60 seconds so that a portion of the metal electrode 130 is formed into metal silicide," such as a ruthenium silicide layer (column 12, lines 16-27; and column 13, lines 7-14). Thus, Kuroiwa et al. utilize independent deposition steps followed by a heat treatment to form a portion of the metal electrode 130 into ruthenium silicide.

Kuroiwa et al., however, fail to teach a semiconductor device structure that includes a chemical vapor codeposited diffusion barrier layer of $RuSi_x$ over at least a portion of a surface, as recited in claims 45 and 50 of the present invention. In other words, Kuroiwa et al. describe a multi-step process of chemical vapor depositing the metal electrode using materials that do not include silicon, and then heat treating the metal electrode with silicon to form ruthenium silicide. So, unlike the present invention, Kuroiwa et al. teach forming the ruthenium silicide layer 132 through silicidation, not through chemical vapor deposition. Thus, the teaching of Kuroiwa et al. is in direct contrast to that described in claims 45 and 50 where the $RuSi_x$ is codeposited, i.e., the $RuSi_x$ is deposited by CVD using a ruthenium precursor and a silicon precursor.

Furthermore, one skilled in the art would understand that a codeposited $RuSi_x$ layer exhibits many structural differences over a ruthenium silicide layer formed by silicidation as taught by Kuroiwa et al. For example, a chemical vapor codeposited $RuSi_x$ layer includes a more uniform distribution of silicon throughout the layer, whereas a silicidated ruthenium silicide layer exhibits a gradient of silicon content from the ruthenium/silicon interface to the opposite surface of the ruthenium layer. Further, a silicidated ruthenium silicide layer may include uneven island formations of silicide instead of a more uniform $RuSi_x$ formed by chemical vapor codeposition.

As such, Applicants respectfully submit that Kuroiwa et al. fail to teach all the elements recited in claims 45 and 50 of the present invention. Thus, Applicants respectfully submit that Kuroiwa et al. fail to anticipate claims 45 and 50 under 35 U.S.C. §102.

Claims 46 and 51

Claims 46 and 51 each depend, either directly or ultimately, from one of claims 45 and 50. As such, claims 46 and 51 are not anticipated by Kuroiwa et al. for the same reasons

as presented above for claims 45 and 50. In addition, claims 46 and 51 each recite additional elements that further support patentability when combined with the respective claims 45 and 50 from which they depend.

For at least the above reasons, Applicants respectfully submit that Kuroiwa et al. fail to teach all the elements recited in claims 46 and 51 of the present invention. Thus, Applicants respectfully submit that Kuroiwa et al. fail to anticipate claims 46 and 51 under 35 U.S.C. §102.

Based on the remarks presented herein above, Applicants respectfully request that the Examiner reconsider and withdraw the rejections under 35 U.S.C.§102.

Rejection under 35 U.S.C. §103

Kuroiwa et al. in view of Aoyama et al.

The Examiner rejected claims 48-49 and 54-68 under 35 U.S.C. §103 as being unpatentable over Kuroiwa et al. (U.S. Patent No. 6,239,460) in view of Aoyama et al. (U.S. Patent No. 5,852,307). Applicants respectfully traverse this rejection.

"To establish a *prima facie* case of obviousness . . . the prior art reference (or references when combined) must teach or suggest all the claim limitations." M.P.E.P. § 2143.

Applicants respectfully submit that the cited documents do not teach or suggest all of the language recited in the present claims. For example, Kuroiwa et al., which has been discussed herein above, fails to teach or suggest a chemical vapor codeposited $RuSi_x$ diffusion barrier layer. Applicants respectfully submit that Aoyama et al., which "relates to a semiconductor device, and in particular to a semiconductor device provided with a capacitor comprising a dielectric film made of a metal oxide, and to a method of manufacturing the semiconductor device" (column 1, lines 6-9), fails to cure the deficiencies of Koroiwa et al.

Thus, Applicants respectfully submit that the Examiner has failed to establish a *prima facie* case of obviousness of claims 48-49 and 54-68 under 35 U.S.C. §103.

Kuroiwa et al. in view of Aoyama et al., and in further view of Matsubara et al.

The Examiner rejected claims 52 and 53 under 35 U.S.C. §103 as being unpatentable over Kuroiwa et al. (U.S. Patent No. 6,239,460) in view of Aoyama et al. (U.S. Patent No. 5,852,307) and further in view of Matsubara et al. (U.S. Patent No. 5,122,923).

Applicants respectfully traverse the rejection.

As discussed herein above, Kuroiwa et al. in view of Aoyama et al. fail to teach or suggest a chemical vapor deposited $RuSi_x$ diffusion barrier. Applicants respectfully submit that Matsubara et al., which has been discussed herein above in the traverse of the rejection under 35 U.S.C. §102, fails to cure the deficiencies of Kuroiwa et al. in view of Aoyama et al.

As such, Applicants respectfully submit that the Examiner has failed to establish a *prima facie* case of obviousness of claims 52 and 53 under 35 U.S.C. §103.

Applicants respectfully request reconsideration and withdrawal of the rejections under 35 U.S.C. §103.

Product-by-Process Limitation

The Examiner asserted that the "limitation "chemical vapor codeposited" merely recites a method of forming and does not deviate from the **structure of a diffusion barrier made by $RuSi_x$** (e.g., page 7, lines 14-15 of the Office Action mailed June 2, 2004, emphasis in original). Applicants respectfully traverse this characterization.

Applicants respectfully submit that the phrase "chemically vapor codeposited" is a structural limitation of the claimed apparatus rather than a process limitation and, as a result, must be evaluated like any other limitation found in the claims (*see, for example, Hazani v. U.S. Int'l Trade Comm.*, 44 U.S.P.Q.2d 1358, 1363 (Fed. Cir. 2000), holding that the limitation "chemically engraved" is not a product-by-process limitation).

For example, in Applicants' Declaration Under 37 C.F.R. §1.132" (filed on January 27, 2003), chemical vapor deposition is an objective feature observable by inspection of the device structure (*see, for example*, paragraph 10: "if a chemical vapor deposited diffusion barrier layer and a sputter coated diffusion barrier layer were analyzed by one skilled in the art these structural differences . . . would allow one . . . to identify the diffusion barrier layer as either being a sputter coated diffusion barrier layer or a diffusion barrier layer having been deposited by a different technique (e.g., chemical vapor deposited diffusion barrier layer)"). ***Thus, the phrase "chemical vapor codeposited" is itself a structural limitation that must be evaluated during examination of the claims.***

As such, Applicants respectfully request that patentable weight be given to the language "chemical vapor codeposited."

Summary

It is respectfully submitted that all pending claims are in condition for allowance and notification to that effect is respectfully requested. The Examiner is invited to contact Applicants' Representatives, at the below-listed telephone number, if it is believed that prosecution of this application may be assisted thereby.

Respectfully submitted for

Vaartstra et al.

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CERTIFICATE UNDER 37 CFR §1.10:
"Express Mail" mailing label number: EV 201890683 US Date of Deposit: October 4, 2004
The undersigned hereby certifies that the Transmittal Letter and the paper(s) and/or fee(s), as described hereinabove, are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR §1.10 on the date indicated above and is addressed to Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

By: _____
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